

EP 30424 (11)

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :

G06F 1/16, F16M 13/00, H05K 7/12,  
G11B 33/14, H05K 5/00, 7/16, F16F  
16/00, F16M 1/00

A1

(11) International Publication Number:

WO 99/06902

(43) International Publication Date:

11 February 1999 (11.02.99)

(21) International Application Number: PCT/US98/15310

(22) International Filing Date: 30 July 1998 (30.07.98)

(30) Priority Data:

08/904,070

31 July 1997 (31.07.97)

US

(71) Applicant: FUJITSU LIMITED [JP/JP]; 1015, Kamikodanaka  
Nakahara-ku, Kawasaki-shi, Kanagawa 211 (JP).(71)(72) Applicant and Inventor: SILVERMAN, Ira, J. [US/US];  
4721 N. First Street #1, San Jose, CA 95134 (US).(72) Inventor: PAPADOPOULOS, Ted; 5146 Cordoy Lane, San  
Jose, CA 95124 (US).(74) Agents: MacPHERSON, Alan, H. et al.; Skjerven, Morrill,  
MacPherson, Franklin & Friel LLP, Suite 700, 25 Metro  
Drive, San Jose, CA 95110 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR,  
BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE,  
GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ,  
LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW,  
MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ,  
TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent  
(GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent  
(AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent  
(AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT,  
LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI,  
CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

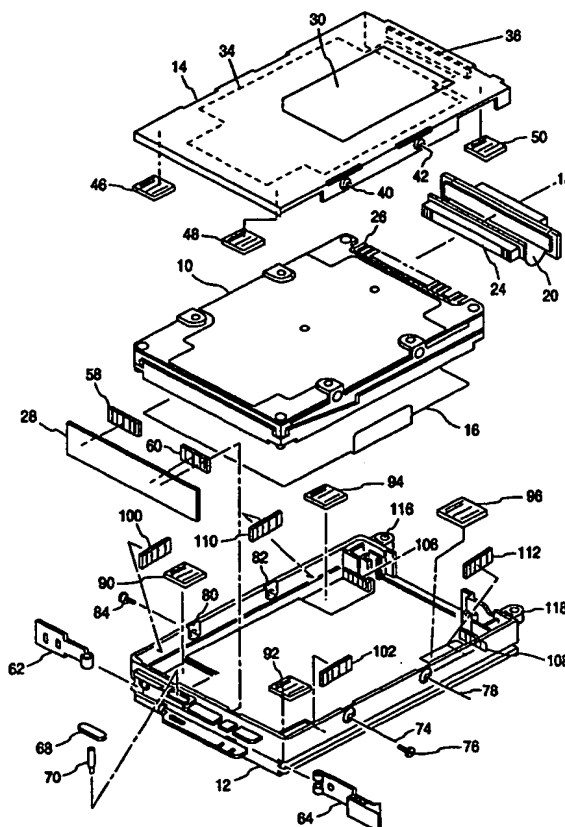
Published

With international search report.

(54) Title: SHOCK MOUNT FOR HARD DISK DRIVE IN A PORTABLE COMPUTER

## (57) Abstract

A hard disk drive assembly for a portable computer includes a conventional small form factor hard disk drive which is mounted in a rigid housing; the housing is mounted to the portable computer chassis. The hard disk drive itself is shock and vibration protected from the housing by a set of thin shock pads of a shock absorbing material such as a viscoelastic polymer. The pads are e.g. 1 or 2 mm thick, typically no more than 5 mm thick. The pads are each relatively small in surface area and are interposed between all surfaces of the hard disk drive and the opposing surfaces of the housing, thereby suspending the hard disk drive in the housing with shock and vibration protection, without the shock pads themselves occupying a significant volume.



**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

SHOCK MOUNT FOR HARD DISK DRIVE  
IN A PORTABLE COMPUTER

5

BACKGROUND

Field of the Invention

This invention relates to disk drives and personal  
10 computers, and more specifically to a shock mounting  
for a hard disk drive in a portable computer.

DESCRIPTION OF THE PRIOR ART

Personal computers are well known, as are portable  
15 personal computers, hereinafter referred to as portable  
computers. Most portable computers now sold include a  
hard drive disk drive (Winchester disk drive). A  
typical "form factor" for hard disk drives currently  
used in portable computers is two and a half inches,  
20 meaning the nominal diameter of the disk is two and a  
half inches. The typical overall size of such a hard  
disk drive is approximately four inches by three inches  
by one-half inch. In a portable computer, the hard  
disk drive is usually the component most sensitive to  
25 shock and vibration since it is the only rotating  
component, and it is mechanically complex. In use, the  
disk in the hard disk drive rotates at a high speed and  
a read/write head rides very closely above the disk.  
The head/disk arrangement is very sensitive to both  
30 vibration and shock and is easily damaged by either.

A typical shock parameter for a portable computer is that the portable computer can be dropped six inches onto a hard surface (e.g. table top) and that the hard disk drive itself sustains a maximum of 100G  
5 acceleration. It is to be understood that the hard disk drive itself is mounted within some sort of housing, typically metal and/or plastic, which is attached to the chassis of the portable computer.

To limit the shock to the hard disk drive to 100G,  
10 a typical prior art solution is to swathe the entire hard disk drive in a thick layer of very soft (polymer gel) material. This has the advantage of providing shock protection due to the softness of the material, and also eliminating transmission of vibration to the  
15 hard disk drive since the polymer gel dampens vibration. While effective, this approach has the drawback that the polymer gel material must be fairly thick, e.g. 3/8 inch thick or more. This is a significant problem, especially with the smaller types  
20 of portable computers where internal volume is at a premium. In this case, the shock mounting material undesirably occupies more volume than does the hard disk drive itself inside the computer.

Also, of course, such shock mounting material is  
25 typically thermally insulative. This may be a problem since the hard disk drive includes a rotational drive motor and a head motor which generate heat which must be dissipated. Hence, this prior art solution, while effective in terms of shock and vibration isolation, is  
30 far from ideal in terms of portable computer system

design. An improved shock mounting system which would be highly desirably would consume less volume and also not be thermally insulative.

## 5 SUMMARY

In accordance with this invention, a hard disk drive is shock mounted within a housing in a portable computer. The shock mounting is a number of thin shock pads each having a small surface area. The shock pads are e.g. one or two millimeters thick, typically no more than five millimeters thick. Each shock pad is a shock absorbing material such as a viscoelastic polymer. The shock pads are collectively fairly small in surface area, e.g. 20% or less of the total surface area of the main top and bottom surfaces of the hard disk drive are covered by the shock pads. Most of the space between the outer surface of the hard disk drive and the inner surface of the housing is empty, or it may be used in one embodiment for installation of thermally conductive pads to provide an efficient heat path between the hard disk drive and e.g. the housing for heat dissipation.

These shock pads provide optimum shock and vibration isolation compared to that in the prior art, but occupy only an insignificant amount of volume since the shock pads are thin. The actual surface area of the shock pads and their thickness is determined so as to provide sufficient shock isolation while also minimizing application of resonant frequency vibrations to the hard disk drive from the portable computer.

Hence, the actual thickness and surface area of the shock mount is dependent upon the size and mass of the hard disk drive, as well as any resonant frequencies from which the hard disk drive must be protected.

5        This shock mounting is compatible with the usual sorts of housings for hard disk drives. For instance, in one embodiment the housing is a rigid box consisting of a bottom tray portion and a covering lid portion in which the hard disk drive fits. The shock mount pads  
10 are disposed between the inner surface of the housing and the outer surface of the hard disk drive. This housing in turn slides inside the portable computer on rails which are mounted on the portable computer chassis.

15        In another embodiment, the housing tray is mounted inside the portable computer on the chassis. The hard disk drive fits inside the tray and is isolated therefrom by the shock pads. A cover fits over the hard disk drive and is also isolated from the hard disk  
20 drive by additional shock pads. This cover in turn is part of an outer surface of the portable computer. Of course, other types of housings are compatible with the present shock pad structure.

      Also, while the presently disclosed shock mounting  
25 is directed to a hard disk drive, it is not so limited. As will be readily understood by one skilled in the art, in addition to a hard disk drive, this scheme may be used with a floppy disk drive or with other types of disk drives. Of course, in the floppy disk (or other  
30 replaceable disk) drive embodiment, the front surface

of the disk drive must be exposed through the outer housing of the portable computer. Otherwise the structures and methods disclosed herein for shock mounting are applicable to other than hard disk drives and also are not limited to the portable computer environment.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows an exploded view of a disk drive assembly in accordance with this invention.

Figures 2A, 2B show the disk drive assembly of Figure 1 as it is being installed into a portable computer.

Figure 3 shows use of heat conductive pads in accordance with this invention in a disk drive assembly.

#### DETAILED DESCRIPTION

Figure 1 shows an exploded (disassembled) perspective view of a disk drive assembly in accordance with this invention. The associated portable computer is not shown; see Figure 2 for this. It is to be understood that Figure 1 is somewhat simplified because it does not show all conventional details of the depicted structures, but only the relevant elements. In addition, while a particular embodiment is shown here, this is not intended to be limiting. Many of the construction details disclosed herein are conventional and are subject to modification. Hence, the presently disclosed embodiments are illustrative and not

limiting. Also, the particular dimensions and materials described herein are, in general, not limiting but are intended to be illustrative. Hence while the presently disclosed embodiments are for a particular size and mass hard disk drive this is not limiting; in the future hard disk drives may be of other sizes and shapes, and the present shock mounting in general is applicable to changes in the disk drive and the housing.

Moreover the disclosed details of the shock pads and their location and surface areas are only illustrative and are intended to provide a certain amount of shock and vibration protection; if greater or lesser amounts of shock or vibration protection are needed, the size, thickness and location of the shock pads would be changed, as will be readily understood by one of ordinary skill in the art.

Figure 1 shows the hard disk drive 10 which is a commercially available type disk drive. The illustrated disk drive is a 2 1/2 inch form factor hard disk drive but this is not limiting; other form factors are possible. Also, the disk drive may be in other embodiments a floppy disk drive or other type of disk drive. The details of hard disk drive 10 are not illustrated nor are any of its internal components shown since they are hidden from view and are conventional.

In the lower portion of the drawing, the next major structure is the tray 12 which in this case is the lower portion of the housing, cooperating with the



upper portion of the housing, which is the cover 14.

(The references to upper, lower, etc., are only with reference to the drawing and have no operational significance, since the disk drive may operate in any attitude and may be mounted in the personal computer in a variety of attitudes.) In this embodiment the tray 12 is, e.g. molded plastic and the cover 14 is e.g. sheet metal, but this is not limiting. It is to be understood that when assembled, all of these components are assembled together into a single structure.

Shield 16 is a thin piece of conductive material e.g. aluminum, which serves as an RF shield.

At the right hand portion of hard disk drive 10 its electrical connection 18 is a plug which electrically connects to the other portions of the portable computer via flexible cable 20 which connects to a second connector 24 which in turn plugs into pins 26 on the outside of the hard disk drive 10.

At the left hand side of the hard disk drive 10 there is a spacer of e.g. plastic 28. As can be seen, spacer 28 fits against the left hand inner edge of the tray 12. (The spacer 28 is not a necessary part of the structure.)

Structure 14 is only a label on the cover 14. The tray 14 also includes insulator structure 34. Opening 36 in the right hand edge of tray 14 accommodates the electrical connector 18. The right hand side of the cover 14 includes screw holes 40 and 42.

For purposes of clarity, the actual shock pads are shown hatched. Those shock pads which have a

horizontal orientation (with respect to the drawing) have horizontal hatching whereas those shock pads which have a vertical orientation (with respect to the drawing) have vertical hatching. Illustrated in the upper portion of Figure 1 are three horizontally oriented shock pads 46, 48, and 50; a fourth such shock pad is not shown because it is not visible in the drawing; it is located in the upper right hand corner of cover 14. In the assembled disk drive assembly, these shock pads 46, 48, 50 are captured between the inner surface of cover 14 and the corresponding upper outer surface of hard disk drive 10, with one shock pad located in each corner of cover 14. This corner arrangement is not limiting, other position are possible.

To give an idea of dimensions, a 2 1/2 inch form factor hard disk drive is 100 millimeters long and 70 millimeters wide and 13 millimeters thick, and weighs approximately 150 grams. Therefore in this embodiment the corresponding inner dimensions of the cover 14 and tray 12 are approximately the same, but slightly larger in order to accommodate both the hard disk drive and the shock pads. In this case shock pads 46, 48, 50 are each 15 millimeters long by 10 millimeters wide by 2 millimeters thick, and of a viscoelastic polymer which is a commercially available shock absorbing material. Such material is available in a variety of thicknesses. Examples of suitable viscoelastic polymer materials are Sorbothane from the Sorbothane Company, rubber materials of the type available from the E.A.R. Co.,

and a Japanese sourced material, similar to Sorbothane, called Sorbo.

In this case the shock pads are provided with adhesive on one surface so that they readily adhere in a permanent fashion to the inner surface of cover 14. The shock pads alternately are adhered to the outer surface of the hard disk drive 10. Since sorbothane is somewhat sticky by itself, in other embodiments no such adhesive is needed and the shock pads are merely placed between the cover 14 and hard disk drive 10 and kept in place by pressure. It has been understood that when assembled, cover 14 and tray 12 hold the hard disk drive between them in fixed fashion with the only contact between the cover 14 and the hard disk drive 10 being via the various shock pads. The same is true of the contact between hard disk drive 10 and the tray 12. Thereby the shock pads provide shock and vibration protection for hard disk drive 10.

In the center portion of Figure 1, vertically arranged shock pads 58 and 60 are interposed between the inner surface of spacer 28 and the corresponding surface of hard disk drive 10 in order to isolate hard disk drive 10 from the spacer 28. The spacer 28 is in intimate contact with the corresponding inner surface of tray 12. Of course in other embodiments no such spacer is required.

With regard to the lower portion of Figure 1, there are several structures which are part of the housing and are shown merely for illustration. These structures include two latches 62 and 64 which latch

the hard disk drive assembly into the personal computer. As can be seen, latch pawl 62 fits into the housing. Handle 64 slides latch panel 62 in and out, to allow the disk drive assembly to be removed from the portable computer as needed. The latch is fastened by latch hardware 68 and 70.

Also shown in tray 12 are screw holes 74 and 78. Hole 74 is shown with its associated screw 76; the screw associated with screw hole 78 is not shown. In the left hand portion of tray 12 are screw holes 80 and 82 with the associated screw 84 for screw hole 80. There is of course a screw associated with screw hole 80. It is to be understood that when assembled, screw hole 40 is coaxial with screw hole 74 and screw hole 42 is coaxial with screw hole 78. There are corresponding screw holes in the left hand portion of cover 14 which are respectively coaxial with screw holes 80 and 82. Thereby the screws 84, 76 etc. assemble together the housing.

With reference to the tray 12, in this embodiment four shock pads 90, 92, 94 and 96 are horizontally mounted at respectively each inner corner of tray 12.

Eight vertically mounted shock pads are associated with tray 12, including shock pads 58, 60. The other six shock pads are, at the left hand portion of tray 12, shock pads 100 and 102, and at the right hand portion of tray 12, shock pads 106 and 108 which are on the right hand inner surface of tray 12, and shock pads 110 and 112 which are located on the same surface as shock pads 100 and 102. Shock pad 108 is not readily

visible in Figure 1 and hence is shown partly in dotted line. For purpose of illustration, shock pads 106 and 108 are shown in their assembled position, while all the other shock pads are shown in a disassembled position.

Rings 116 and 118 in Figure 1 may be used for mounting the disk drive housing to the portable computer chassis by screws. These are not an essential portion of this structure since other mounting arrangements are possible.

The dimensions of the horizontally mounted shock pads 90, 92, 94 and 96 are the same as that of the horizontally mounted shock pads 46 etc.; this is not limiting. The vertically mounted shock pads 100, 102, 106, 108, 110, 112 in Figure 1 are in this embodiment 15 millimeters long by 10 millimeters wide by 1 millimeter thick.

Thus it can be seen for instance that with reference to shock pads 46, 48, 50, that each of these has a surface area of 150 square millimeters for a total shock pad surface area of 600 square millimeters. (The fourth shock pad in this group is not illustrated.) This is in contrast to the approximately 7,000 square millimeters which is the surface area of the upper surface of hard disk drive 10. Thus in this example less than 10 percent of the surface area of the top of hard disk drive 10 is actually in contact with shock pads. This has been found to provide optimum vibration protection; that is, if there were more shock pads or the shock pads were larger, undesirable

resonant frequencies are amplified by the shock pad arrangement, disturbing operation of the hard disk drive.

It is to be understood that the particular  
5 arrangement of shock pads shown in Figure 1 is not limiting. The arrangement is a matter of design considerations depending on the configuration of the particular housing, the size of the hard disk drive, the mass of the hard disk drive, and any resonant  
10 frequencies to which the hard disk drive is to be exposed. Also of course the thickness of the shock pads is dependent on the amount of shock to be sustained. This particular shock pad arrangement is intended to limit shock transmitted to the hard disk  
15 drive 10 to 100G when the portable computer is dropped from 6 inches onto a hard surface.

Therefore the present shock mounting system is a trade-off of vibration vs. shock protection. While equal or better shock protection would be provided by  
20 more completely enclosing the hard disk drive in the viscoelastic polymer, this has been found undesirably to result in excessive amplification of vibration, due to the thinness of the present shock pad materials.

One particular viscoelastic polymer used here for  
25 the shock pads has a durometer measurement (hardness) of 50 shor A. Again this is not limiting. Other shock absorbing materials may require different configurations of the shock pads in terms of thickness and surface area.

Figure 2A shows in a top view the hard disk drive assembly 134 of Figure 1 in the process of being inserted into a portable computer 136. Shown in detail in Figure 2B (dotted lines) are the rails 140, 142 upon  
5 mounted on the chassis of the portable computer and upon which the outer surface of the hard disk drive assembly tray 12 rides. Figures 2A, 2B show how the housing of Figure 1 is used in a particular portable computer and hence are only illustrative.

10 A housing differing somewhat in its mounting arrangement from that of Figure 1 is used in other embodiments. For instance, in one embodiment the tray (or equivalent structure) instead of sliding on rails on the portable computer is permanently installed in  
15 the portable computer, e.g. mounted to the portable computer chassis. In this case in order to provide access to the hard disk drive (which is often removed for service or replacement due to its relative fragility), the cover 14 is typically a portion of the  
20 outer housing of the portable computer. Hence the cover 14 is removable, allowing access to the hard drive which may be easily removed from the tray 12. In this case, there are no rails but otherwise the arrangement is similar to that of Figure 1, with the  
25 exception that latch elements 62, 64, etc. are not needed. The present shock mount is also applicable to permanently mounted disk drive housings and to permanently mounted hard disk drives.

The Figure 1 arrangement is improved upon in  
30 accordance with yet another embodiment of the invention

illustrated in Figure 3. This embodiment is for use in relatively high heat environments, e.g. portable computers having high performance microprocessors which tend to be hot inside. In this case an additional  
5 structure is provided to remove heat from the hard disk drive, because in this case the air circulation between the housing and the hard disk drive itself is not adequate for heat removal.

Therefore in this case as shown in a top view in  
10 Figure 3, additional heat conductive structure is provided. Figure 3 is a top "x-ray" view of the assembled hard disk drive assembly showing structures which would normally not be visible; only pertinent structures of Figure 1 are shown, for simplicity. The  
15 structures shown in Figure 3 are generally the same as in Figure 1 except for heat conductive pads 120, 122, 124, 126, 128, 130 which are co-planar with shock pads 46', 47', 48' and 50' and are of approximately the same thickness as the shock pads, and thereby in contact  
20 with both the upper surface of hard disk drive 10 and the inner surface of cover 14. Note that shock pads 46', 47', 48', 50' are in somewhat different locations than are corresponding shock pads 46, 48, 50 in Figure 1. This illustrates one possible variation in the  
25 shock pad arrangement.

Unlike the shock pads, heat conductive pads 120, 122 etc. are of a heat conductive material. However, they may have no particular shock or vibration isolation properties, but serve only to conduct heat  
30 from the hard disk drive 10 to for instance the (metal)



cover 14 which thereby acts as a heat sink. The actual surface area and shape of the heat conductive pads 120, 122 etc. is determined by how much heat conduction is needed. Again, the arrangement shown in Figure 3 is only one illustrative embodiment of the heat conductive pads. The heat conductive pads may instead be located between the hard disk drive 10 and the tray 12 where the tray 12 is a heat conductive structure, or where a heat sink is provided on the inner surface of tray 12.

One advantage of the arrangement of Figure 1 is that there is indeed space for air to flow between hard disk drive 10 and cover 14 and tray 12 since the total surface area of the shock pads is limited. This is a substantial improvement over the prior art where the hard disk drive is swathed in the shock absorbing material, which thereby undesirably also serves as a thermal insulator.

The presently disclosed embodiments are illustrative and not limiting; further modifications will be apparent to one skilled in the art in the light of this disclosure and are intended to fall within the scope of the appended claims.

WE CLAIM:

1. A shock mounted disk drive assembly  
comprising:

a disk drive;

5 a housing for the disk drive, the housing  
being adapted for mounting in a computer;

a plurality of spaced apart shock pads  
suspending the disk drive in the housing, each  
shock pad being of a shock absorbing material and  
10 no thicker than 5 mm and being in contact with an  
outer surface of the disk drive and an inner  
surface of the housing.

2. The assembly of Claim 1, wherein each shock  
15 pad is no thicker than 2 mm.

3. The assembly of Claim 1, wherein the disk  
drive has a top and bottom and side surfaces, and the  
shock pads disposed on each of the top and bottom  
20 surfaces collectively occupy no more than 10% of an  
area of each of the top and bottom surfaces.

4. The assembly of Claim 1, wherein the shock  
pads are of a viscoelastic polymer.

25

5. The assembly of Claim 4, wherein the shock  
pads are of Sorbo, Sorbothane, or rubber.

6. The assembly of Claim 1, wherein the shock pads are each adhered to at least one of the disk drive and housing.

5        7. The assembly of Claim 1, further comprising at least one thermally conductive pad disposed between an outer surface of the disk drive and an inner surface of the housing.

10       8. The assembly of Claim 1, wherein the housing comprises a tray and an associated cover, the tray being adapted to slide onto mounting rails in the computer.

15       9. The assembly of Claim 1, wherein the housing comprises a tray mounted on the personal computer and an associated cover which is an outer surface of the computer.

20       10. A method of shock mounting a disk drive in a computer, the computer including a housing for the disk drive, comprising the steps of:

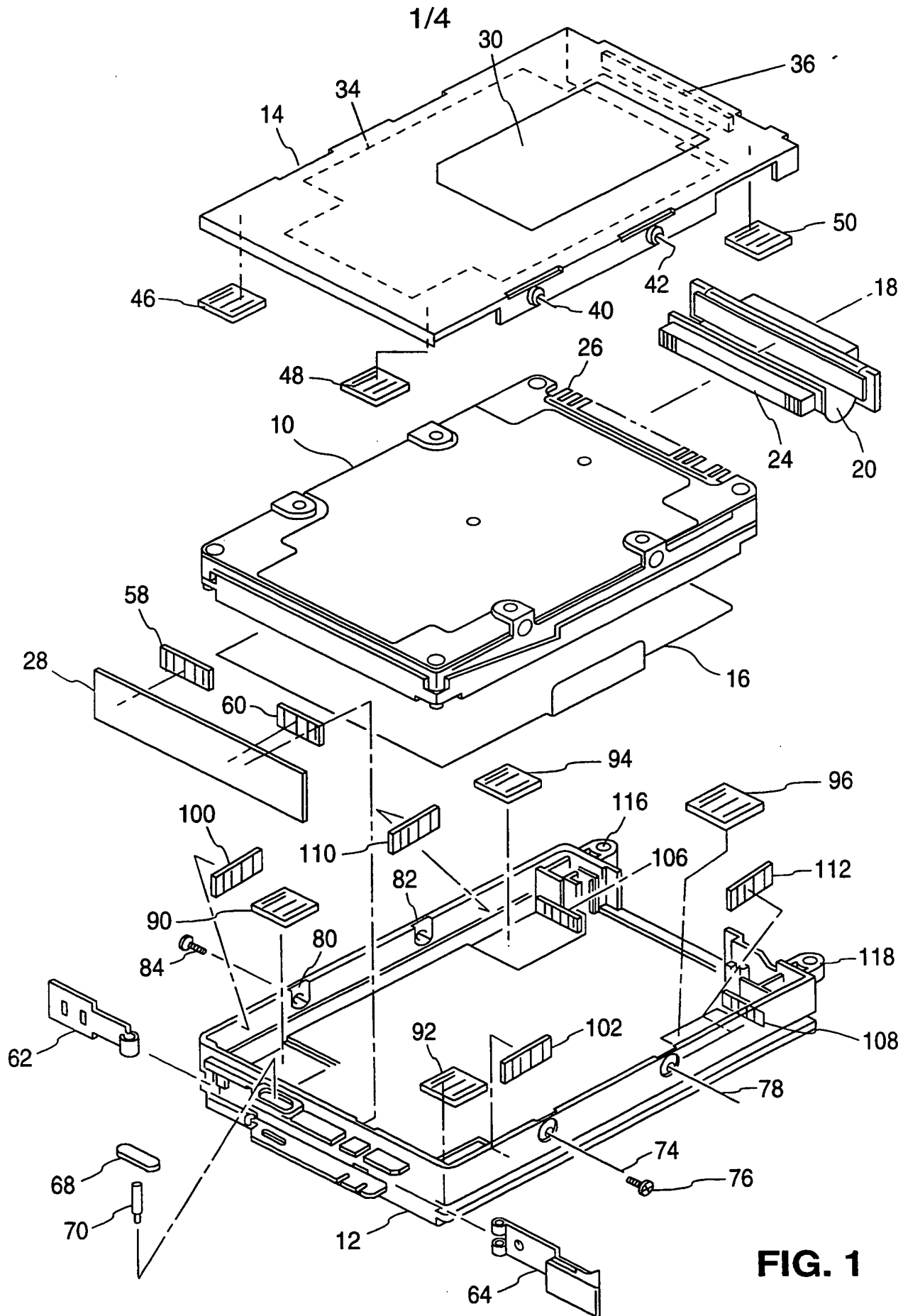
flexibly suspending the disk drive in the housing at a plurality of spaced apart locations, these being at least two locations for each top, bottom, and side surface of the disk drive;

25

wherein in a suspended position each top, bottom and side surface of the disk drive is no more than 5 mm from an associated surface of the housing; and

30

selecting a surface area of the suspension locations so as to avoid amplifying selected resonant frequencies.

**FIG. 1**

SUBSTITUTE SHEET (RULE 26)

2/4

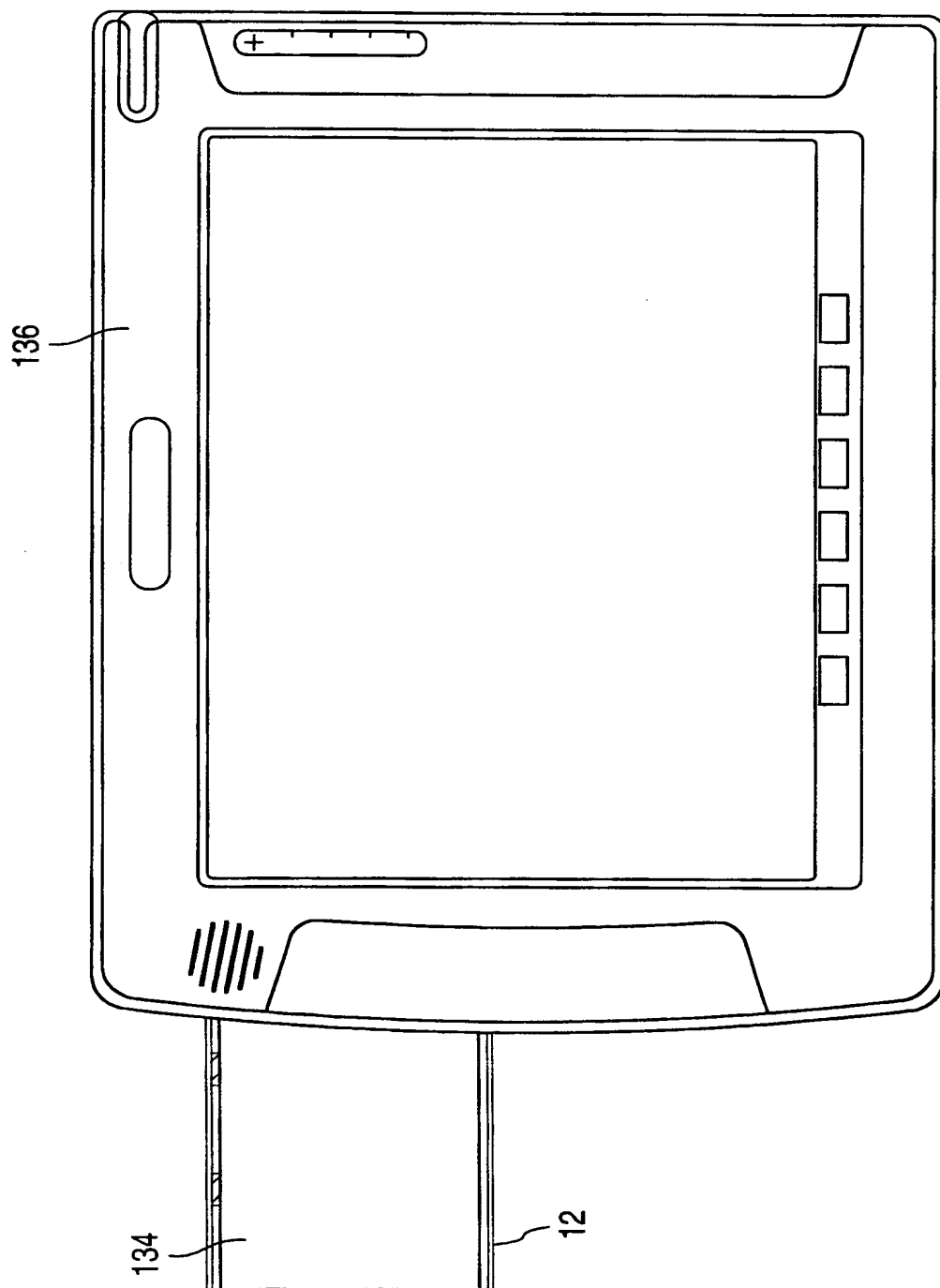
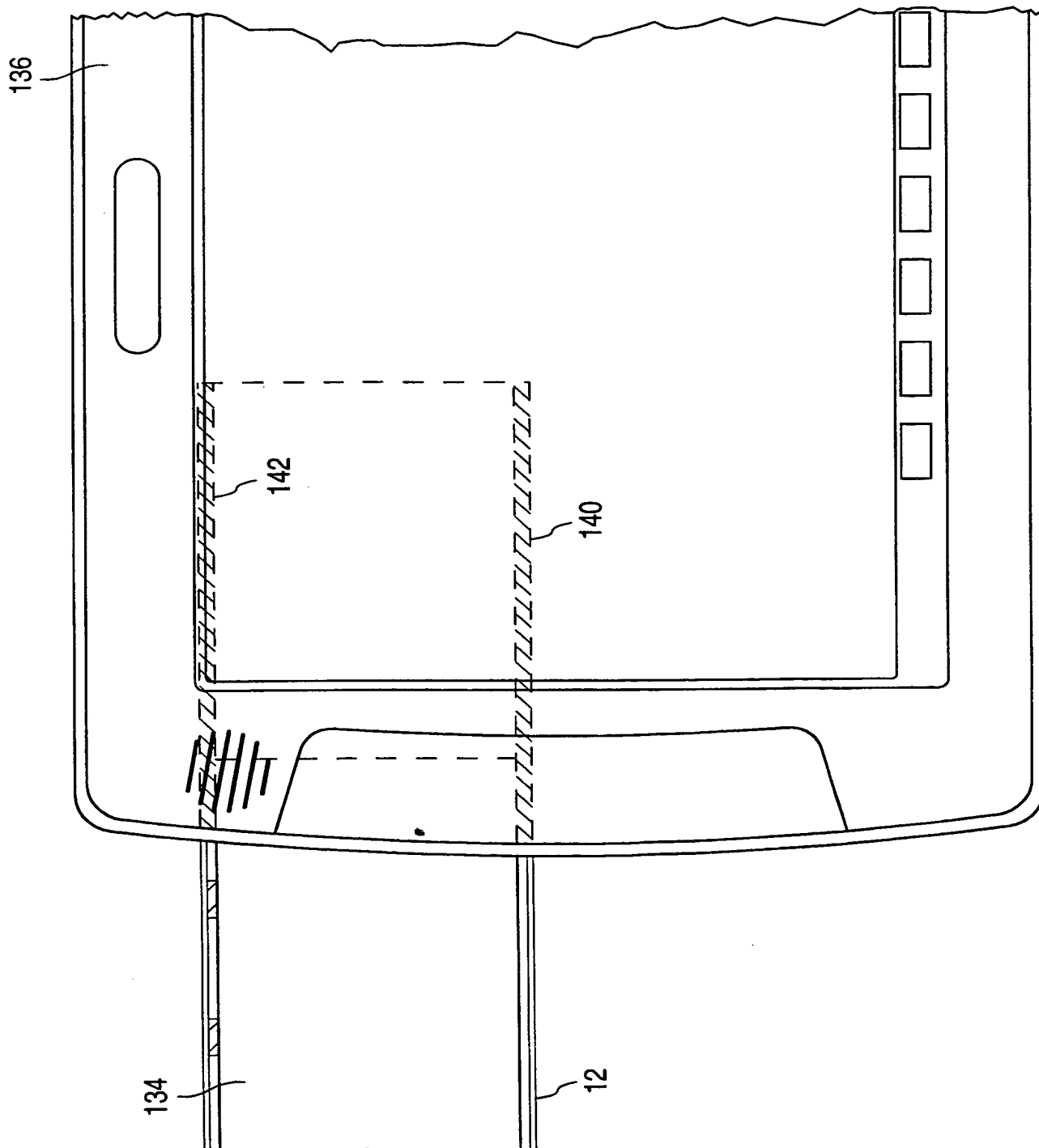


FIG. 2A

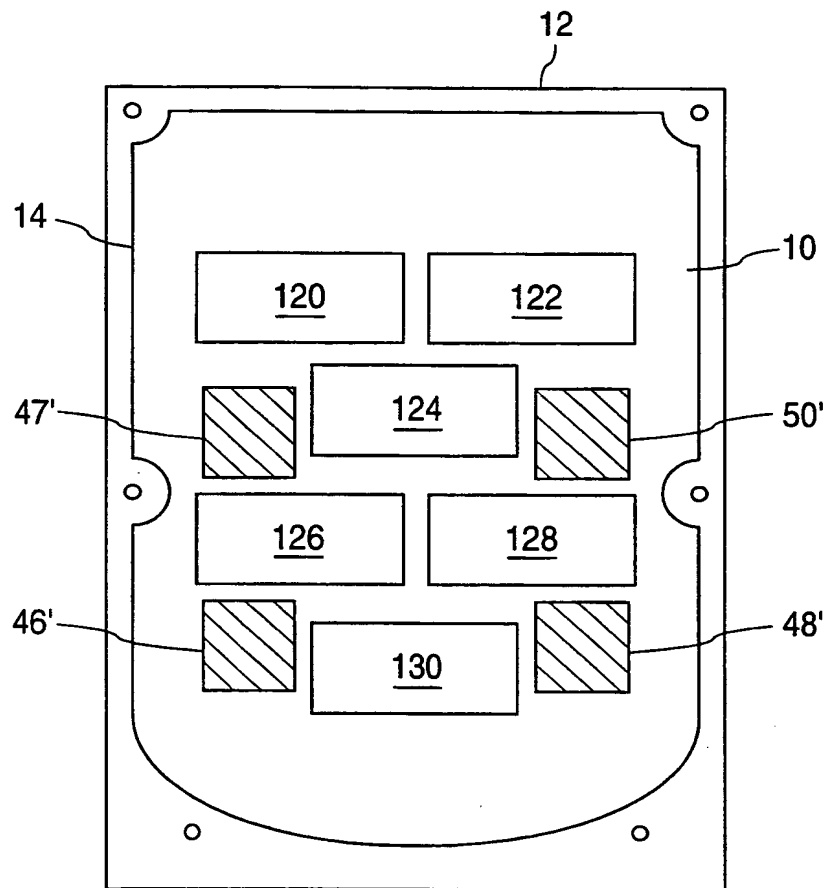
3/4

FIG. 2B



SUBSTITUTE SHEET (RULE 26)

4/4



**FIG. 3**



## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US98/15310

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : Please See Extra Sheet.

US CL : 361/685

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 361/685, 687, 704, 707; 248/609, 632, 633, 634, 638

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
NONEElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
NONE

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,980,786 A (O'Sullivan et al.) 25 December 1990 (25/12/90) in its entirety	1-8, 10
Y	US 5,557,499 A (Reiter et al.) 17 September 1996 (17/09/96) in its entirety	9
Y	US 5,463,527 A (Hager et al.) 31, October 1995 (31/10/95) in its entirety	1-6, 10
Y	US 5,402,308 A (Koyanagi et al.) 28 March 1995 (28/03/95) in its entirety	1-3, 6, 9 10
Y	US 5,491,608 A (Koyanagi et al.) 13 February 1996 (13/02/96) in its entirety	1-3, 6, 9, 10
Y	US 5,216,582 A (Russell et al.) 01 June 1993 (01/06/93) col. 5, lines 3-5	4,5

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*B* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z* document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

19 OCTOBER 1998

Date of mailing of the international search report

03 NOV 1998

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

LISA LEA-EDMONDS

Telephone No. (703) 308-1782

## INTERNATIONAL SEARCH REPORT

 International application No.  
 PCT/US98/15310

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,P	US 5,673,171 A (Varghese et al.) 30 Septembr 1997 (30/09/97) in its entirety	1-8, 10
Y	US 5,349,486 A (Sugimoto et al.) 20 September 1994 (20/09/94) in its entirety	1-6, 8, 10
Y	US 4,896,777 A (Lewis) 30 January 1990 (30/01/90) in its entirety	1-6, 8-10
Y	US 5,366,200 A (Scura) 22 November 1994 (22/11/94) in its entirety	1-5, 10
Y	US 3,191,896 A (T. D. Nathan) 29 June 1965, (29/06/65) in its entirety	1-5
Y	US 3,436,042 A (W. Van Goubergen) 01 April 1969 (01/04/69) in its entirety	1-5
Y	US 4,436,274 A (Kramer) 13 March 1984 (13/03/84) in its entirety	1-5
Y	US 5,478,058 A (Tucchio et al.) 26 December 1995 (26/12/95) in its entirety	1-5
Y	US 4,002,315 A (Van Goubergen) 11 January 1977 (11/01/77) in its entirety	1-5
Y	US 4,685,303 A (Branc et al.) 11 August 1987 (11/08/87) in its entirety	1-8, 10

**INTERNATIONAL SEARCH REPORT**

International application No.  
PCT/US98/15310

**A. CLASSIFICATION OF SUBJECT MATTER:**

IPC (6):

G06F 1/16; F16M 13/00; H05K 7/12; G11B 33/14; H05K 5/00; H05K 7/16; F16F 16/00; F16M 1/00

THIS PAGE BLANK (USPTO)